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Microleakage of Amalgam Restoration with Adhesive Resin Cement Lining, Glass Ionomer Cement Base and Fluoride Treatment

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The effect of an adhesive resin cement (Panavia) lining in reducing microleakage of amalgam restorations with or without a glass ionomer base and fluoride treatment was examined. The prepared forty-eight cavities were assigned to 6 groups: amalgam restoration (Group I, control), amalgam restoration with Panavia lining (Group II), amalgam restoration with Lining Cement base (Group III), amalgam restoration with Lining Cement base + Panavia lining (Group IV), amalgam restoration with Lining Cement base + Ag $(NH_3)_2F$ treatment + Panavia (Group V), and amalgam restoration with Ag $(NH_3)_2F$ + Lining Cement + Panavia (Group VI). After 100 thermal cycles, the teeth were immersed in 1% methylene blue. The degree of dye penetration was scored and assessed.

The use of Panavia as an adhesive liner (Group II) was effective in reducing microleakage of freshly placed amalgam restorations. The Panavia lining with a Lining Cement base (Group IV) was more effective, and the Panavia lining with the combination of Ag $(NH_3)_2F$ treatment and a Lining Cement base (Group VI) was most effective.

Key words: Microleakage, Amalgam, Resin cement lining

INTRODUCTION

Since dental amalgam is not adhesive to tooth structures, microleakage usually occurs at the amalgam-tooth interface, especially in freshly placed amalgam restorations[1]. Our previous study revealed that amalgam was adhered to the tooth hard tissues when adhesive resin cement was mediated between the amalgam and tooth tissues[2]. The application of resin cement as a liner before amalgam restoration may decrease the microscopic space between amalgam and the cavity walls, and consequently it might be effective in reducing microleakage around amalgam restorations.

The effect of the adhesive resin cement lining in reducing microleakage of amalgam restorations with or without a glass ionomer cement base and fluoride treatment was examined.

MATERIALS AND METHODS

Twenty-four extracted human premolars were used. Forty-eight cavities with an outline similar to that of a class V cavity were prepared, one on the mesial and one on the distal surface of each tooth. The dimensions of the preparations were approximately 1.5 mm occlusogingivally, 4 mm buccolingually, and 1.5 mm deep. The cavities were prepared with a diamond point in a high-speed handpiece using a waterspray coolant. All cavity walls were finished with a fissure bur.

Table 1 The treatment procedures of each groups prior to amalgam restorations

Group	Treatment
I (control)	no treatment
II	etching + Panavia*
III	Lining Cement**
IV	Lining Cement** + etching + Panavia*
V	Lining Cement** + Ag $(NH_3)_2F$† + etching + Panavia*
VI	Ag $(NH_3)_2F$† + Lining Cement** + etching + Panavia*

Note:
* Panavia (Kuraray) was used as a liner.
**Lining Cement (G-C) was used as a base.
† 38% Ag $(NH_3)_2F$ solution (Saforide, Toyo Seiyaku Kasei) was applied for 3 min.

The prepared cavities were randomly assigned to 6 groups. Table 1 shows the treatment procedures of each group prior to amalgam restoration. A resin cement, Panavia*, was used as an adhesive liner. A glass ionomer cement, Lining Cement**, was applied to the cavity floor as a base. A fluoride, 38 % Ag $(NH_3)_2F$ (Saforide †), was applied for 3 min to the cavities of two groups. After these treatments, the amalgam †† was inserted into the cavity, condensed, and carved to the carvosurface. The teeth were stored in distilled water at 37°C for 24 h. Then the restorations were polished with silicone points.

The teeth were then thermocycled for 100 cycles to simulate the temperature change in the mouth. Each cycle consisted of 2 min in a 60°C hot bath, and 2 min in a 4°C cold bath. After thermocycling, the teeth were immersed in a 1 % methylene blue solution for 24 h.

The teeth were then ground longitudinally both from buccal and from lingual surfaces, and approximately 1.5 mm thick sections including the middle part of the restoration were prepared.

The degree of dye penetration at the tooth-restoration interface was assessed separately for occlusal and gingival walls on both surfaces of each section. Dye penetration was scored according to the criteria described in Fig. 1 by three examiners.

RESULTS

The assessment of dye penetration was made separately for occulusal and gingival walls on both surfaces of each section, a total of 32 sites being examined for marginal leakage in each group (Table 2). Figure 2 shows the marginal leakage assigned to three categories (none: score 0, moderate: scores 1 and 2, severe: scores 3 and 4).

In the experimental groups without Ag $(NH_3)_2F$ treatment, Groups II, III and IV, 16-38 % of the cavities had no leakage, 9-34 % moderate leakage and 32-56 % severe leakage, whereas in the control group 87.5 % had severe leakage and 12.5 % moderate leakage (Fig. 2).

With a Lining Cement base followed by Ag $(NH_3)_2F$ treatment (Group V), 25 % of the

* Kuraray Co., Kurashiki, Japan
** GC Co., Tokyo, Japan
† Toyo Seiyaku Kasei Co., Osaka, Japan
†† Spherical D, Shofu Co., Kyoto, Japan

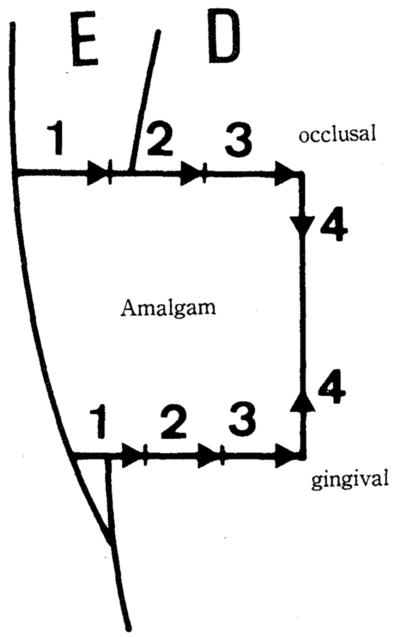

Fig. 1 Scoring system for assessment of dye penetration.
0=no penetration
1=penetration up to one third of cavity depth
2=penetration up to two thirds of cavity depth
3=penetration up to complete cavity depth
4=penetration of dye up to the axial wall

Table 2 Assessment of marginal leakage by depth of dye penetration

Score of dye penetration		Cont	Exp				
		Group I	Group II	Group III	Group IV	Group V	Group VI
0	occlusal / gingival	0 / 0 } 0	5 / 0 } 5	8 / 4 } 12	7 / 4 } 11	5 / 3 } 8	13 / 10 } 23
1	occlusal / gingival	1 / 0 } 1	2 / 0 } 2	0 / 0 } 0	6 / 1 } 7	2 / 5 } 7	2 / 4 } 6
2	occlusal / gingival	3 / 0 } 3	4 / 3 } 7	2 / 1 } 3	1 / 3 } 4	6 / 5 } 11	1 / 1 } 2
3	occlusal / gingival	1 / 0 } 1	4 / 6 } 10	5 / 9 } 14	2 / 1 } 3	3 / 3 } 6	0 / 1 } 1
4	occlusal / gingival	11 / 16 } 27	1 / 7 } 8	1 / 2 } 3	0 / 7 } 7	0 / 0 } 0	0 / 0 } 0
Total	occlusal / gingival	16 / 16 } 32	16 / 16 } 32	16 / 16 } 32	16 / 16 } 32	16 / 16 } 32	16 / 16 } 32

Note: Table indicates the number of occlusal and gingival sites examined for assessment of dye penetration.

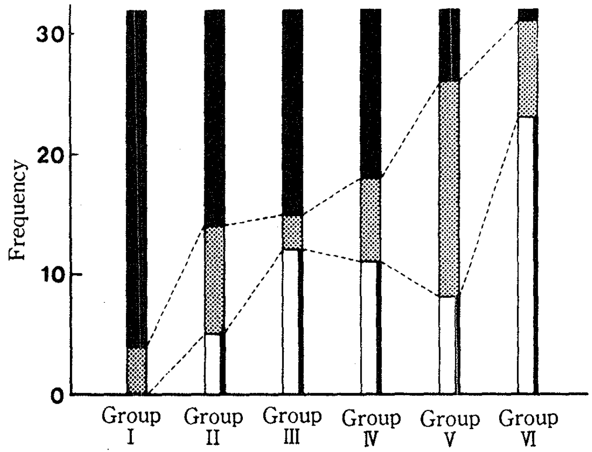

Fig. 2 Diagram illustrating the degree of marginal leakage assigned to three categories:
□ none (score 0)
▨ moderate (scores 1 and 2)
■ severe (scores 3 and 4)

cavities had no leakage, 56 % had moderate leakage and 19 % had severe leakage (Fig. 2). With Ag $(NH_3)_2F$ treatment followed by a Lining Cement base (Group VI), 75 % had no leakage, 25 % had moderate leakage, and only 3 % had severe leakage (Fig. 2).

DICCUSSION

The traditional low copper amalgam and the high copper amalgam show a different pattern of leakage. Fayyad and Ball[3] showed that *in vitro* corrosive treatment improved the marginal seal of the traditional low copper amalgam, but had no effect on the marginal seal of high copper amalgam. Andrews and Hembree[4] reported that the leakage around the amalgam with high copper alloy did not subside for a longer period than the amalgam with the traditional alloy.

The reason for this reduction in leakage of traditional amalgam may be a deposition of corrosive products in the amalgam-tooth interface[5]. However even traditional amalgam shows a great deal of microleakage during the first few months until the corrosion products seal the space[1]. As corrosion of amalgam relates to the presense of the γ_2 phase found in the traditional amalgam[5], the high copper amalgam which has little or no γ_2 phase would not form corrosion products[6]. Oral fluid, acid and microorganisms may penetrate freely into the space between amalgam and cavity walls[7] and this leakage could play a substantial role in both postoperative sensitivity[1] and the development of secondary caries[7]. Therefore, to obtain a successful and long lasting amalgam restoration, in particular with a high copper amalgam restoration, the space must be sealed and the leakage at the very moment of amalgam restoration must be kept mimimal.

The use of the resin cement, Panavia, as an adhesive liner (Group II) was effective in reducing microleakage of freshly placed amalgam restorations. The use of a Panavia lining with a Lining Cement base (Group IV) was more effective, and the Panavia lining with the combination of Ag $(NH_3)_2F$ treatment and a Lining Cement base (Group VI) was the most effective. Part of resin cement applied to the cavity walls prior to amalgam restoration would remain in the space between amalgam and cavity walls, and excess Panavia would be squeezed out with the condensation of amalgam. Panavia left between the tooth-amalgam interface cures in several minites and would seal the space. Since Panavia is an anaerobic curing resin, it does not cure until the cavity is filled with amalgam. This anaerobic curing property allows enough working time for amalgam restoration, and is recommended for in clinical use. On the other hand, a self curing type of resin cement, such as Super Bond‡, is liable to cure itself before amalgam insertion. Therefore this type of resin cement, even though it has good bonding and sealing ability, is inadequate.

Cavity varnishes are effective in reducing microleakage of amalgam restorations[1,8,9]. Cavity varnish, however, is only a sealing material·which does not serve the purpose of a bonding agent at all. Panavia used in this study not only seals the space between the amalgam-tooth interface but also adheres amalgam to tooth structures[2].

Treatment with a 38% Ag $(NH_3)_2F$ solution followed by a Lining Cement base and Panavia lining (Group VI) reduced the microleakage markedly compared to Group IV except for the application of Ag $(NH_3)_2F$. This reduction in leakage might be due to increased affinity of Panavia to tooth structures treated with Ag $(NH_3)_2F$. Previously, we found that bond strength to the enamel and dentin treated with Ag $(NH_3)_2F$ increased somewhat[2].

In addition fluoride treatment increased the resistance of tooth structures to carious attack. In fact, the topical application of fluoride to the prepared cavity enhanced the carious resistance of cavity walls[10,11] and inhibited secondary caries effectively [12-14]. The treatment of Ag $(NH_3)_2F$ + Lining Cement + Panavia (Group VI) seems to be most effective in reducing microleakage, and inhibiting postoperative sensitivity and secondary caries in amalgam restoration and adhering amalgam steadily to tooth structures.

CONCLUSION

The effect of a Panavia lining in reducing microleakage of amalgam restorations with or without a Lining Cement base and Ag $(NH_3)_2F$ treatment was examined using extracted human teeth.

The amalgam restorations with a Panavia lining (Group II) reduced microleakage compared to the control (Group I). The amalgam restorations with a Panavia lining and a Lining Cement base (Group IV) showed less dye penetration than the Panavia lining alone (Group II). The Panavia lining with the combination of Ag $(NH_3)_2F$ treatment and a Lining Cement base (Group VI) was the most effective method of reducing microleakage in amalgam restoration. These results suggest that Panavia lining with a cement base and fluoride treatment are very useful for successful amalgam restoration.

‡ Sunmedical Co., Kyoto, Japan

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充塡用グラスアイオノマーセメントの窩洞辺縁ギャップと接着強さ

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グラスアイオノマーセメント6種と対照としてコンポジットレジン2種を使用し，象牙質窩洞で硬化時に生じる辺縁ギャップ，対象牙質せん断接着強さを測定した。両充塡材共に，ギャップの小ささと接着強さの大きさについて24時間値の方が30分値よりすぐれていた。辺縁ギャップ及びせん断接着強さの24時間値については，グラスアイオノマーセメントとコンポジットレジンとの間に差が見られなかった。グラスアイオノマーセメントの1種を使用して粉液比を変化させた場合，粉末量の増加に伴い接着強さ及び圧縮強さは増加し，辺縁ギャップは減少した。これらの間には明らかな関連性が見られた。

冷却中に起る陶材焼付用合金の相変化

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三種類の市販陶材焼付用合金において，1000°Cから室温までの冷却中に起る相変化を電気抵抗測定，X線回折実験，EPMA実験により検討した。それぞれに異なった相変化が検出された。高カラット金合金では Pt_2PdSn の Ll_2 規則相が粒界に，パラジウム基合金では Pd_3In を基本とする面心正方晶が粒内に生成した。低カラット金合金の場合には粒内および粒界において典型的な二相分離反応を呈した。各合金における冷却中の反応は以下の通りである。

高カラット金合金

$\alpha_0(fcc) \longrightarrow \alpha(fcc) + \beta(Ll_2)$

低カラット金合金

$\alpha_0(fcc) \longrightarrow \alpha_1(fcc) + \alpha_2(fcc)$

パラジウム基合金

$\alpha_0(fcc) \longrightarrow \alpha(fcc) + \beta(fct)$

接着性レジンセメントによる裏装がアマルガム修復の辺縁封鎖性に及ぼす影響

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接着性レジンセメントであるパナビアを，アマルガム修復の裏装材として用いた場合，辺縁封鎖性にどのような効果を及ぼすかについて調べた。被験歯としてヒト抜去歯48本を用い，6つのグループに分けた。1つのグループは処理なしの対照群とし，残りのグループはそれぞれの処理を行った後，アマルガムを充塡した。100回の温度変化を与えた後，色素浸透試験を行い辺縁封鎖性を調べた。

その結果，アマルガム充塡に先立ち窩壁歯質にパナビアを塗布することにより，辺縁封鎖性が向上した。パナビアとライニングセメントの裏層を併用することにより，さらに良好な封鎖性が得られた。また，窩壁歯質をサホライドで処理しライニングセメントを置いた後，パナビアを塗布しアマルガムを充塡した場合，最も優れた辺縁封鎖性が得られた。本法を臨床で応用することにより，今までより優れたアマルガム修復が可能となるであろう。